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Date Oct. 15, 1958 Signed Richard E. Reedy
OFFICE SECURITY ADVISOR

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DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
WASHINGTON 25, D. C.

A Preliminary Investigation of the Effects of a Blowing Slot Near the Leading Edge of an Airfoil

By
JOSEPH J. CORNISH III

Conducted For
OFFICE OF NAVAL RESEARCH
Under
Contract Nonr 978(01)

By
THE AEROPHYSICS DEPARTMENT
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Mississippi State College

...earch Note No. 1 April 16, 1954

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Abstract

An investigation was made of the effects of blowing air over the upper surface of an airfoil from slots located at various chordwise positions near the leading edge. Boundary layer profiles were measured to determine the integrated effect of the blowing on the boundary layer. The total head near the surface behind the slot was measured in comparison to the free stream total head as an indication of the extent to which momentum had been restored to the boundary layer. Both the case of impervious upper surface and the case of perforated upper surface with suction applied were considered.

The slot opening was 0.0625 inches or approximately 0.104% chord. The slots were tested at the 0%, 6%, 10% and 20% chord stations. Values of flow coefficient, C_Q, for the slot ranged from .002 to .0025.

Introduction

In order to attain the full lift predicted by potential flow theory, many attempts have been made to decrease the boundary layer losses which cause an airfoil to depart from its potential characteristics. Various methods of suction through perforations, slots, and porous media have been investigated. Also there has been a considerable amount of experimentation concerning the blowing of air through slots both at the leading edge of airfoils (Reference 1) and at the wing-flap juncture (Reference 2.)

This blowing has been accomplished both by artificial means, i.e., by mechanically pumping air to the slot and ejecting it, and by automatic means, i.e., by allowing the high pressure air on the lower surface to escape from the upper surface by means of a slot through the wing as in the case of the leading edge slot or a slotted flap. The former method, artificial blowing, was employed in the present investigation.

Apparatus and Methods

The test vehicle for these tests was a modified Schweizer TG-3 sailplane. The blowing slot was attached to the wing in the form of a cuff on the right wing of the airplane as shown in Figure 1. The spanwise extent of the slot was 3.75 feet. The slot opening was 0.0625 inches, 0.104% of the chord. The jet velocity exceeded the local velocity at the slot by 66 feet per second for all slot locations.

The boundary layer measurements were made with a boundary layer mouse of the usual design with one inch outside tube height. The pressures from the mouse were recorded photographically on a water manometer.

Total head measurements were made with a simple total head tube which could be placed on the wing surface at any desired chordwise position. The total head near the surface was measured with respect to free stream total head on a sensitive airspeed indicator.

A stethoscope of the type described in Reference 3 was used to detect the transition from laminar to turbulent flow in the boundary layer.

Results

The first tests were run with the leading edge impervious and the slot located at the 0% chord station. The boundary layer mouse was attached to the wing at the 30% chord station and profiles were measured with the slot blowing and with the slot inoperative. This same procedure was followed with the slot at the 10% and 20% chord positions. The boundary layer parameters computed from the profiles thus obtained are shown in Figure 2. The change in θ at 30% chord for blower on as compared to blower off is very small except for the case of the slot at 0% chord, in which case the blower actually causes an increase in θ at 30% chord.

In order to get a more detailed picture of the effects of the blowing slot, a series of profiles were made at intervals downstream with the slot located at the 6% chord station. Figure 3 shows these profiles taken at the 7%, 10% and 20% chord positions with the blower on and with the blower off. Only the profile at 7% shows appreciable differences blower on and blower off. The profiles at 20% are almost identical.

The total head near the surface of the airfoil was measured with respect to free stream total head at various positions downstream of the slot. These measurements were made for the case of the slot at 6% chord and the slot at 20% chord. Figure 4 shows that the total head in the boundary layer with the blower on becomes equal to the total head with the blower off at a distance of only 3% chord downstream of the slot at the 6% station. When the slot was moved back to 20% chord, the effect of the blowing could be detected some 8% downstream.

For the purpose of reducing some of the frictional losses in the blowing jet, the leading edge of the wing was perforated in the region downstream of the slot for each slot position tested. More boundary layer profiles were measured at the 30% chord station. The values of θ at 30% chord computed from these profiles are presented in Figure 5. The same general effects are seen as in the case of the impervious wing. The largest effects of the suction occurred with blower off rather than with blower on.

During the investigations, the nature of the flow out of the slot was examined with a stethoscope. In all cases, the flow out of the slot was laminar, however, it became turbulent a short distance downstream of the slot. In all cases, the flow had become turbulent 3% downstream of the slot.

Discussion and Conclusions

The present investigations indicate that the blowing of relatively low velocity air tangentially into the boundary layer from a slot at the surface is an ineffective method of restoring momentum to the boundary layer. The effects of the blowing are apparent for only a short distance downstream of the slot.

It should be noted that there was no attempt to optimize the slot exit configuration, however it is thought that variations in slot shape will not materially affect the above conclusion. Schwier, Reference 2, also found that blowing from a slot at the leading edge was less effective than blowing at the wing-flap juncture.

References

1. Munk, M. M., "Aerodynamics of the Wing Slot," Journal of the Aeronautical Sciences, (1-2) p. 28, January 1934.

2. Schwier, W., "Lift Increase by Blowing out Air, Tests on Airfoil of 12 Percent Thickness, Using Various Types of Flap," NACA TM 1148, June 1947.

3. Raspet, A., "Boundary Layer Studies on a Sailplane," Aeronautical Engineering Review, Vol. 2, No. 6, 1952.

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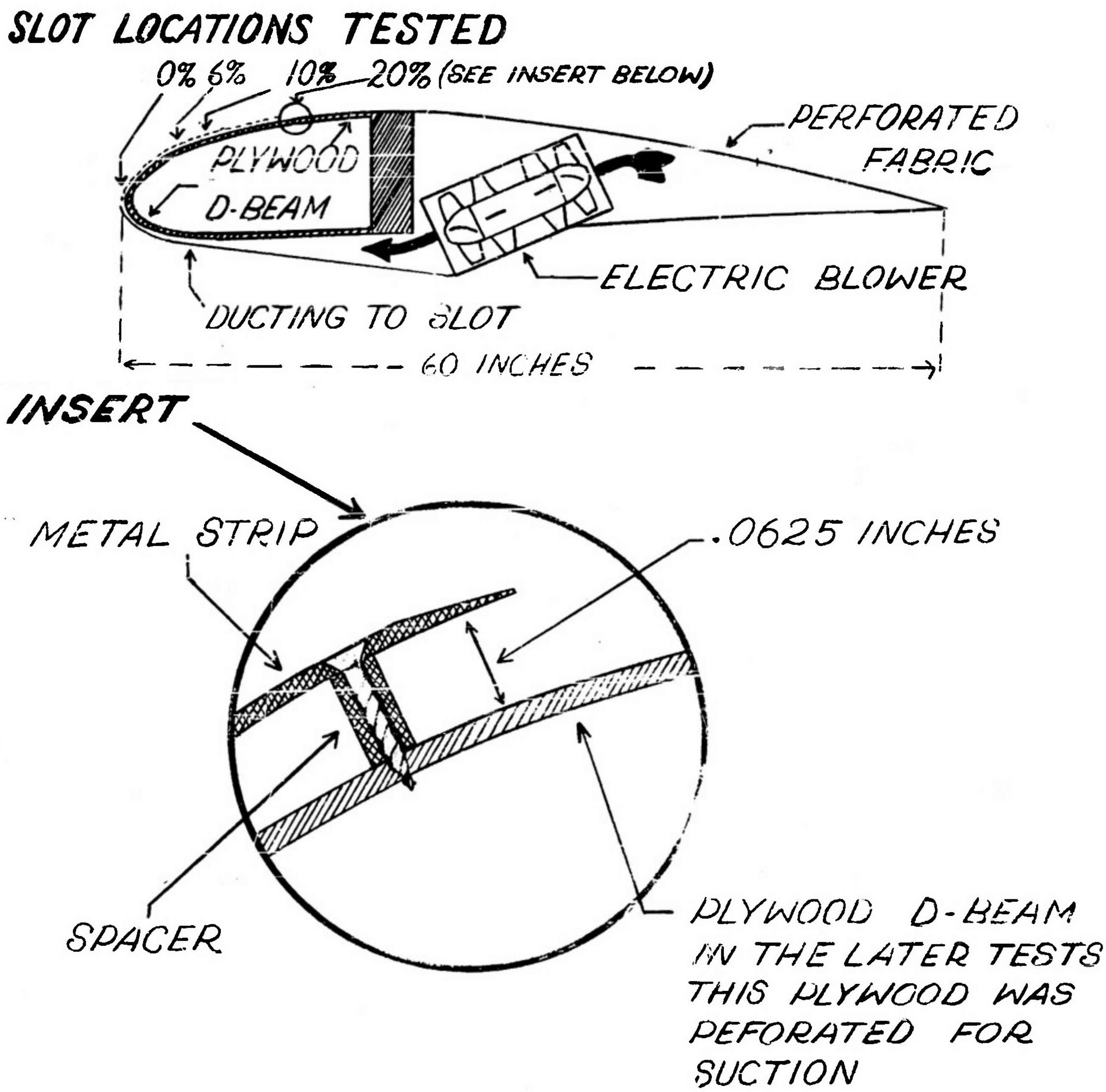
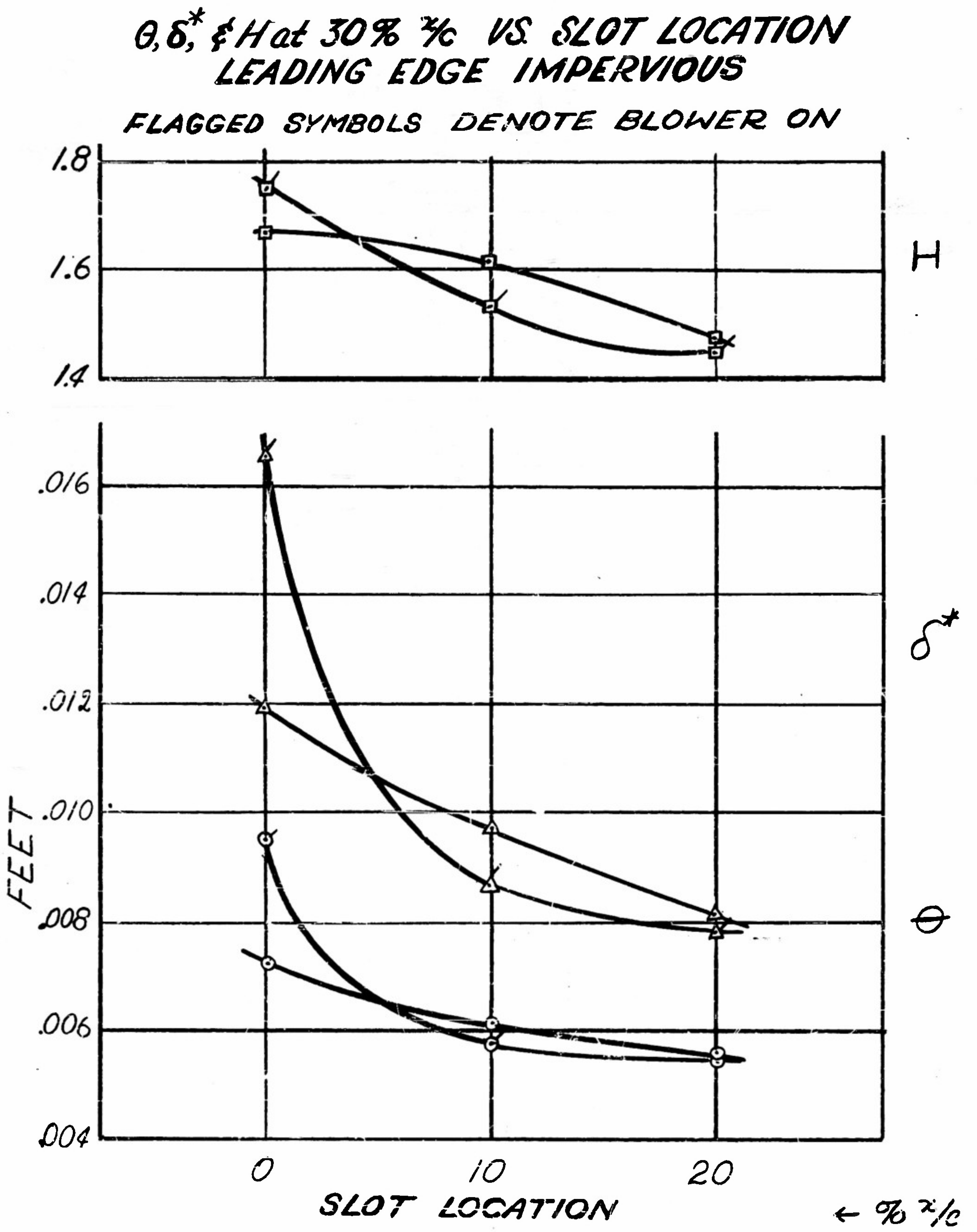
FIG. 1



DETAILS OF BLOWING SLOT

FIG. 2


θ, δ*, & H at 30% x/c VS. SLOT LOCATION
LEADING EDGE IMPERVIOUS
FLAGGED SYMBOLS DENOTE BLOWER ON
1.8
1.6
1.4
H
.016
.014
.012
.010
.008
.006
.004
FEET
δ*
θ
0
10
20
SLOT LOCATION
← % x/c

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BOUNDARY LAYER PROFILES BEHIND SLOT

FIG. 3

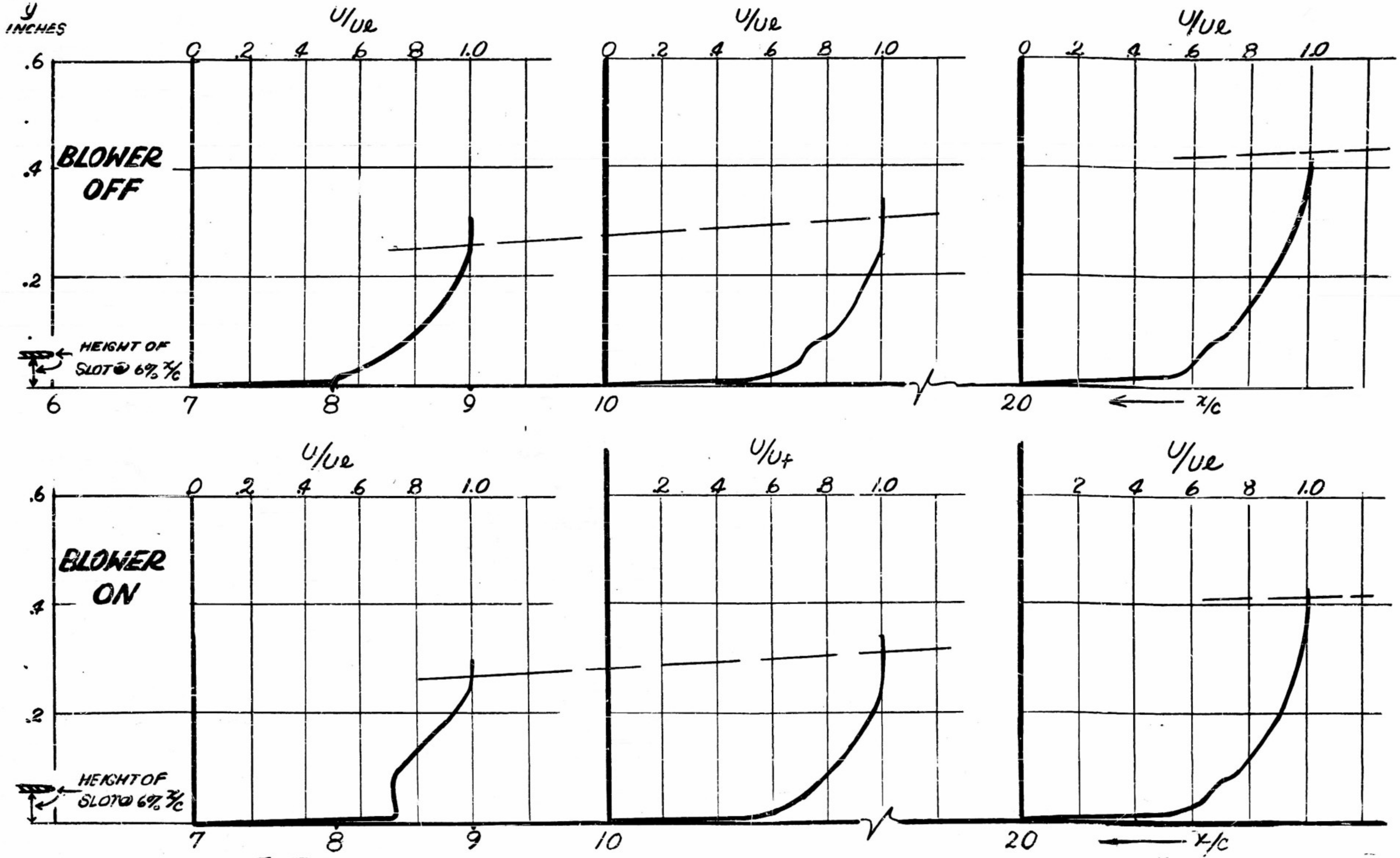

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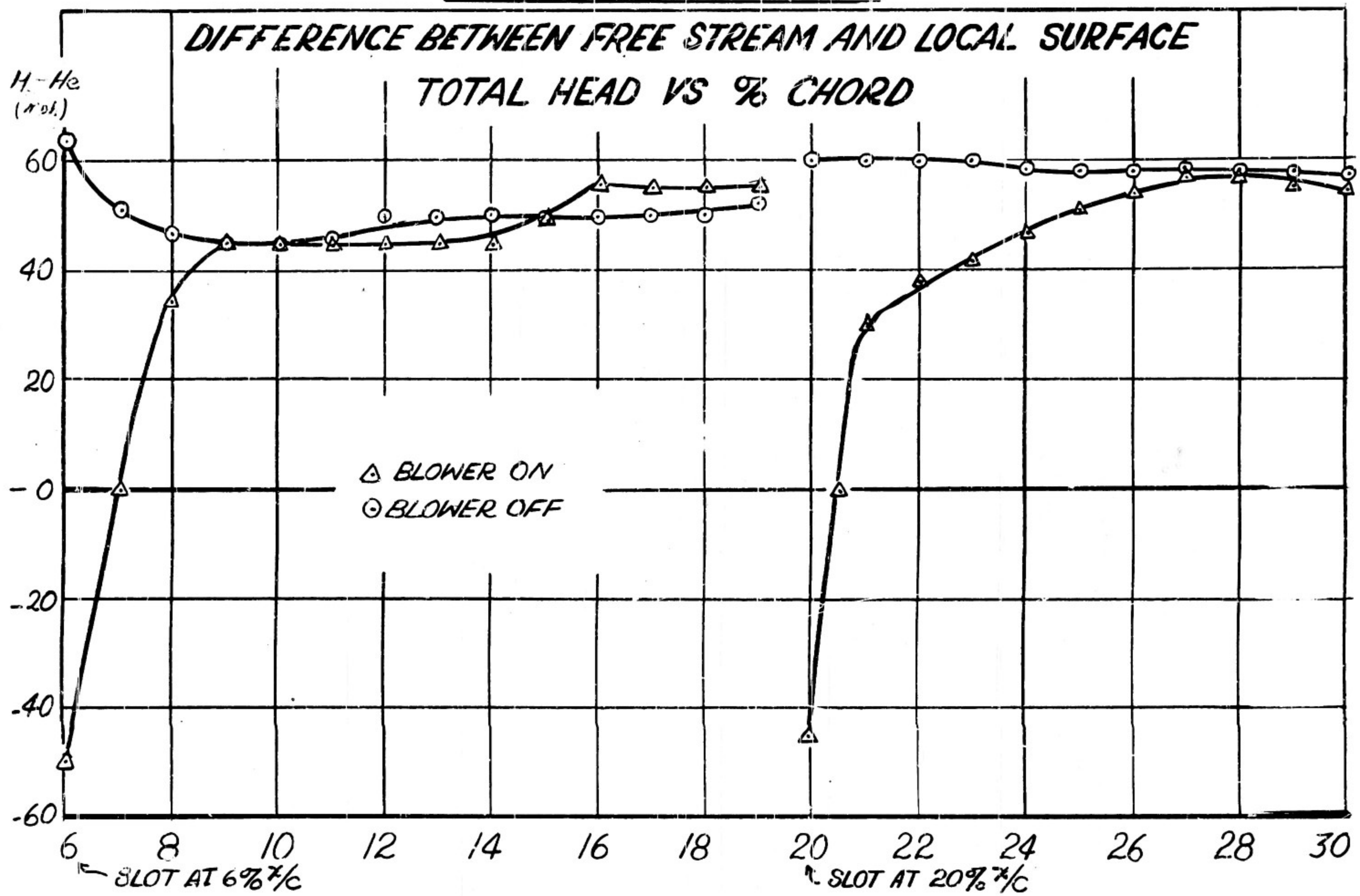
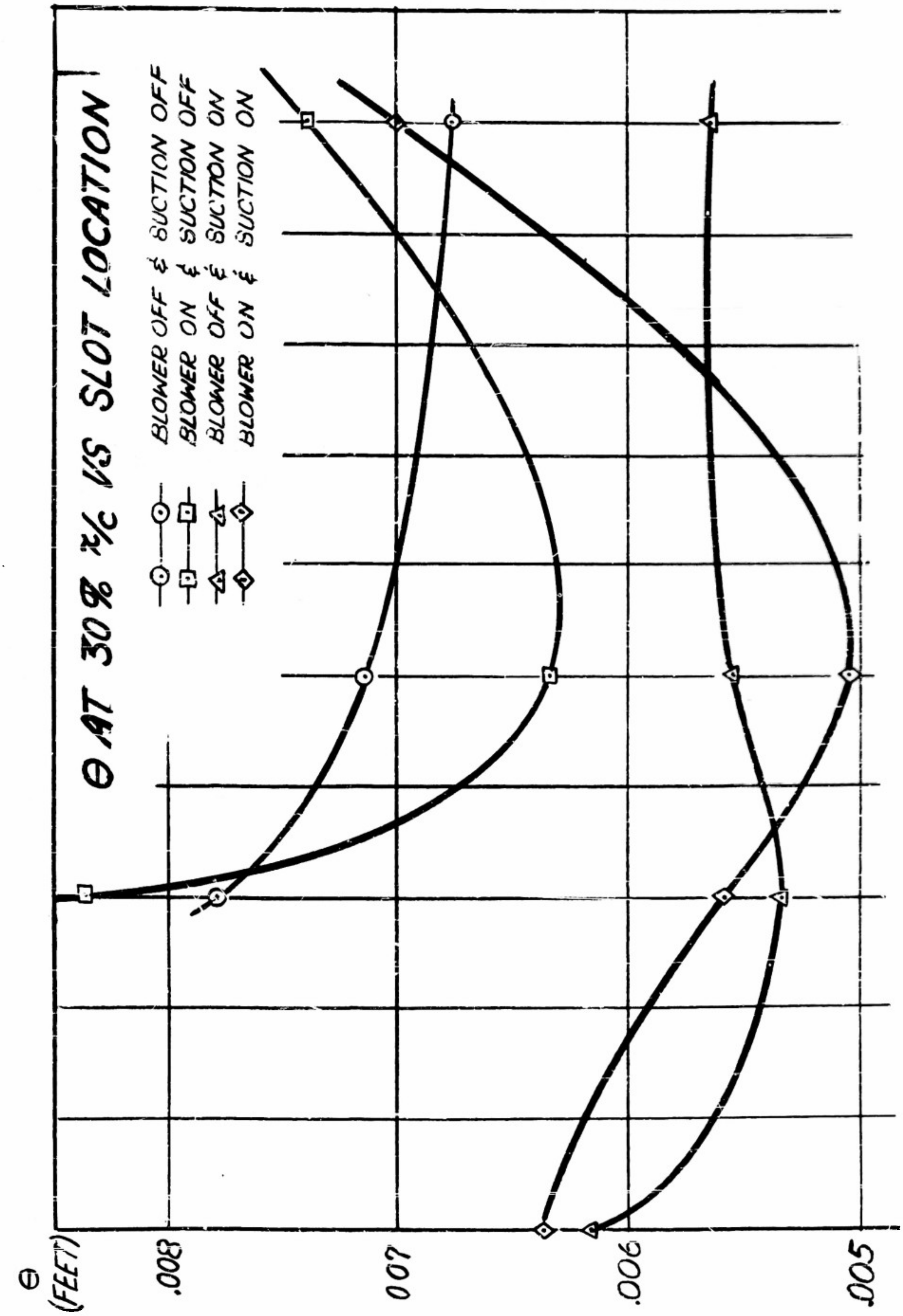
FIG. 4




θ AT 30% x/c VS SLOT LOCATION
BLOWER OFF & SUCTION OFF
BLOWER ON & SUCTION OFF
BLOWER OFF & SUCTION ON
BLOWER ON & SUCTION ON
θ (FEET)
.008
.007
.006
.005

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